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*The Pathogenicity and the Variability
of Fusarium Moniliforme
from Corn*

BY L. H. LEONIAN

AGRICULTURAL EXPERIMENT STATION
COLLEGE OF AGRICULTURE, WEST VIRGINIA UNIVERSITY
F. D. FROMME, Director
MORGANTOWN

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THE PATHOGENICITY OF THE FUNGUS

THE WIDE distribution of *Fusarium moniliforme* Sheldon and its rôle in the ear-rots of corn are now beyond dispute; but the degree of pathogenicity of the different strains of this fungus and their proper place in the seedling-blight diseases of corn are by no means established. Conflicting opinions abound in the literature. Some investigators regard the fungus as possessing no pathogenicity whatever, while others ascribe to it certain serious consequences. Pammel, King, and Seal (16) reported that in 1914 some species of *Fusarium* attacking roots, stalks, and ears of corn caused a loss in Iowa estimated at \$15,000,000.

In his earlier studies Valteau (19) considered *F. moniliforme* to be the most important agent in root and stalk rots of corn. Manns and Adams (13) reported that about twenty percent of the corn in Delaware was internally affected with *F. moniliforme*. Edgerton and Kidder (5), Melchers (15), and Sherbakoff (17) express doubt about the pathogenic nature of this fungus. Holbert *et al* (7) state that while field inoculations have failed to yield definite data concerning the ability of this fungus to cause root rot of corn, certain strains of corn are very susceptible to ear rot by *F. moniliforme*. Hoffer and Carr (6) proposed the theory that the so-called root rot of corn is caused by an excessive amount of aluminum in the soil. Manns and Phillips (14) admit that this fungus is a factor in causing root rot of corn seedlings, but find that in this respect *Gibberella saubinetii* is decidedly the more destructive.

Tehon (18) reports that root and stalk rots of corn are caused by *F. moniliforme* as well as by other organisms, but Branstetter (1), while admitting that under greenhouse conditions this fungus can cause a certain amount of seedling blight, failed to find any case of root rot among the surviving plants. Koehler and Holbert (9) declare that practically every seedlot in Illinois every year is infected with *F. moniliforme*, the percentage of infection frequently being as high as 50 percent. However, they find that the fungus is not a vigorous pathogen and estimate the loss caused by it as only one percent. More recent work by Valteau (20), Branstetter (*l.c.*), and Johann, Holbert, and Dickson (8) indicates that a species of *Pythium* is the most important agent involved in corn root rots, and that *F. moniliforme* is only of secondary importance. Thus it can be seen that while there is not a unanimity of opinion, the weight of evidence seems to incline towards the theory that *F. moniliforme* is not an active root parasite and that at least in the majority of cases it is a secondary invader. Observations made and experimental data assembled by the writer favor this view.

In the summer of 1927 the entire experimental plot of Longfellow Flint corn on the Agronomy farm became heavily infested with what appeared to be a severe case of root rot. The adjoining plots, planted to other varieties, seemed to be free from it. It was soon observed that the disease was a complex one, caused by *Aplanobacter stewarti* (E.F.S.) McCulloch, and *Fusarium moniliforme*. Many of the plants were killed in the late seedling stage; those which survived were badly stunted, most of them prematurely shriveling and drying up. An abundance of bacterial slime oozed from every part of the affected plant; stem, blades, ears, corn grains, and tassels were covered with it. Cross sections of the stem showed an abundance of the characteristic yellow guttation. When these exudates were transferred to nutrient agar, colonies of *Aplanobacter stewarti* were first to form, but about two or three days later hyphae of *F. moniliforme* grew out of the bacterial colony. Tissue cultures of all parts of corn, from roots to young grains, invariably gave similar results. Presumably the bacterium was the aggressive pathogen and the fungus an intimate associate, as many subsequent inoculations failed to produce conclusive evidence that the fungus was capable of causing any destructive effect after the emergence of the corn plant from the seedling state. Nevertheless, it was deemed advisable to secure as many isolants of *F. moniliforme* as possible and to test their relative efficiency in the production of corn root rot. Accordingly, some 150 isolations were made from the roots and the basal parts of the underground stem of corn seedlings in many different localities of West Virginia. Stunted and sickly looking seedlings with discolored roots and mesocotyls were selected for isolation work. About 110 of the foregoing 150 isolations proved to be *F. moniliforme*, 20 were of *F. culmorum* type, and the remaining consisted of different genera and species of saprophytic fungi.

In the first elimination series, inoculations were made on corn growing in 250 cc. flasks, each containing 150 cc. of nutrient agar (Pfeffer's formula). The base of young seedlings near the region of the second node was wounded by a sterile needle and inoculated with bits of hyphae. Soon it became apparent that many isolants did not possess the slightest pathogenicity even under such highly favorable conditions. Therefore some 60 strains were summarily eliminated, and the remaining 50 were tested under greenhouse conditions. At 25° C. or above little or no infection occurred, all other conditions remaining favorable to the fungus. Consequently the greenhouse temperature was kept between 20 and 23°C. as much as possible. Of the 50 isolants of *F. moniliforme* which showed a certain amount of disease producing ability in the corn growing in flasks, some 30 were eliminated because they failed to attack corn seedlings under greenhouse conditions. Longfellow Flint variety was used in most of the experiments, although a number of other varieties, especially Reid's Yellow Dent, were also tried and found to be equally susceptible under favorable conditions.

Inoculation experiments were continued with the remaining organisms for three winters in the greenhouse and for two summers in the

field. From 25 to 50 plants were inoculated with each strain in the field experiments, while in the greenhouse experiments some 15 plants were used with five plants in each pot of two-gallon capacity. As soon as corn seedlings were about five inches above ground, the dirt was removed from the base of plant and the exposed region wounded with a scalpel and covered with a generous amount of rice culture in which the fungus was growing luxuriantly. The dirt was then replaced.

In the successful inoculations the first signs of the disease appeared within a week or ten days, when the lower blades wilted and dried, the entire seedling eventually becoming infected and killed. When the root tips instead of the base of the seedling were inoculated, only local lesions appeared, and in no case death or even decided stunting of the seedlings ensued. (Fig. 1.)



FIG. 1—Inoculation experiments with the different dissociants of the same isolant of *F. moniliforme*. Left to right: check, dissociants XVIII, XII, XIII, VIII, V, and II. Dissociants XVIII and XII show little or no effect upon the corn seedlings, while XIII, VIII, V, and II have stunted and killed the host. This, however, is not a constant behavior, as the reverse may occur upon the repetition of the experiment.

Positive inoculations through sound tissues were comparatively rare. Many factors may be responsible for the wounding of the corn tissues not only in the field but also in greenhouse conditions, and it is more probable to assume that ordinarily few, if any, positive infections occur through sound tissues. This assumption is particularly strengthened by the fact that when in a series of experiments the soil was sterilized, heavily inoculated with rice cultures of *F. moniliforme*, and planted to corn, no seedling diseases could be observed. Similarly, when newly germinated corn seedlings were placed in plates containing vigorously growing colonies of the fungus, kept there until nearly one

half of the roots were infected and killed, and then planted in the greenhouse or in the field, they grew into as vigorous plants as did the checks. Such a severe treatment is conclusive evidence that the fungus is only a weak pathogen, and unless given the opportunity to girdle the base of the seedlings is unable to bring about death or even stunting.

Climatic conditions greatly influence the pathogenicity of this organism. Wet, cool springs seem to be ideal. Seedlings growing in low, moist spots are particularly susceptible. If such conditions continue for very long, the seedlings may be killed by the fungus, but if warmer days follow, they recover quite rapidly. This was demonstrated in field inoculation experiments. Successive plantings at two weeks' intervals, beginning with the middle of April and extending to the middle of July, were inoculated, and the results noted. None of the inoculations made in June or July showed signs of infection, while many of those made in early May yielded diseased seedlings, some of which were soon killed, while others recovered as the temperature rose. By August they were as vigorous as the checks. Temperatures lower than 24°C. favored the fungus, while the higher ones kept the pathogen in check and aided the host plant.

THE VARIABILITY OF THE FUNGUS

EVEN THE MOST vigorous isolants of *F. moniliforme* used in the inoculation experiments were highly inconstant in their ability to bring about positive inoculations. At one time they were able to cause the seedlings to wilt within five days; at other times they were unable to bring about the slightest infection. The inoculation experiments were repeated so often and under such ideal conditions for successful infection that there can be no doubt about the recurrent nature of the pathogenicity of *F. moniliforme*. Since many of the morphological and physiological characters of this fungus are governed by an extreme plasticity, there should be no reason to suppose that pathogenicity may form an exception to the rule.

The dissociating habit of these organisms is very pronounced. Many interesting and widely differing variants have been isolated. One isolant, especially, which appeared to be the most vigorous pathogen, has been studied quite extensively. In the course of one year about 50 dissociants were segregated from a single spore culture of this strain. The more distinctive of these dissociants were used in an extensive series of inoculations in an effort to determine the effect of dissociation on pathogenicity. The results were as inconstant as the macroscopic appearance of the colonies. At one time a given dissociant showed a decided virulence, and at another time it failed to bring about any infection. Apparently there is no rule or order in the behavior of these organisms, and it seems impossible to make any kind of classification of pathogenic and non-pathogenic biotypes.

While certain macroscopic characteristics of these dissociants are fairly constant, many others are extremely fluctuative. One biotype, for instance, is a very slowly growing organism, averaging not more

than 30 mm. in a week at a temperature of 25°C., while all others grow to 80 and 90 mm. in the same length of time. While most of the time this biotype will come true, occasionally it will give rise to new sectors consisting of some one of the other dissociants, or perhaps of a new one. Similarly, the more rapidly growing dissociants may show sectors consisting of this slowly growing type. Furthermore, colorless dissociants give rise to colored ones, and vice versa; sporodochia formers produce dissociants with no ability to form such structures; those possessing aerial hyphae may give rise to some with no such hyphae, or hyphae may be formed by isolants which ordinarily have no aerial hyphae. Such an extreme variability runs the gamut of growth characters. (Fig. 2.)

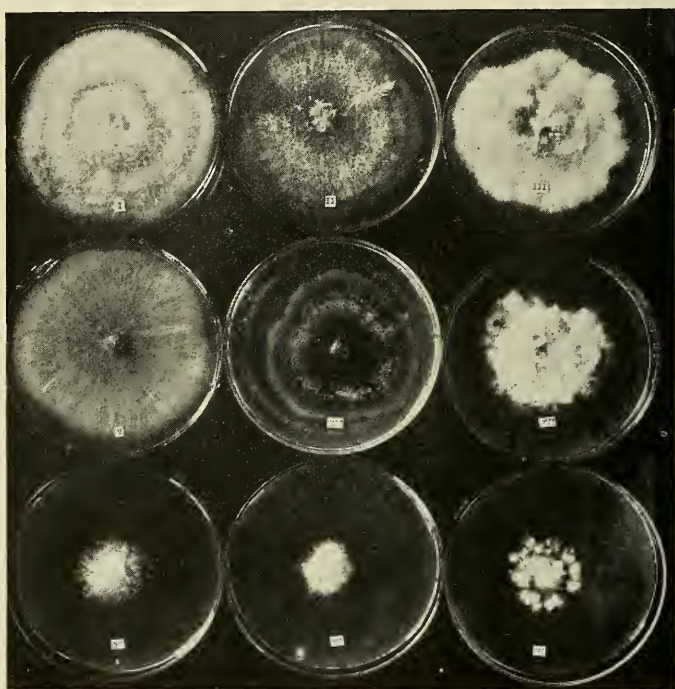


FIG. 2—Representative cultures of the 50 dissociants of a single spore isolant of *Fusarium moniliforme*, grown on the same agar and under identical conditions.

Some of the dissociants, however, fluctuate much less than others, although their stability never even approaches the immutable stage. Undoubtedly a constant selection will serve to fix certain habits, and thus the plastic nature of any given organism may be induced to conform itself to certain limits. This was accomplished with the most persistently dissociating variant, which at first would never form a pure colony, but one where two forms were found intimately associated; this, however, should not be considered a mere mechanical mixture of two organisms, but should be ascribed to a greater complexity of

protoplasm. One of these forms produced white aerial hyphae in great abundance, with the submerged hyphae colorless, or with very faint purple streaks. The other formed no aerial hyphae, and produced intensely purple submerged hyphae. The medium upon which these organisms were grown consisted of proteose peptone 5 grams, dihydrogen potassium phosphate one gram, magnesium sulphate one gram, dextrose 20 grams, and agar-agar 20 grams in 1,000 cc. of water. Transfers made from the purple sector usually gave rise to a large percentage of true-to-type colonies, although sometimes a complex colony with both colorless and colored sectors was also formed. However, transfers made from the colorless colonies failed to yield true-to-type colonies, but gave rise either to seemingly pure purple types, or to complex colonies with both the colorless and colored sectors. Test-tube cultures invariably gave rise to sectoring colonies.

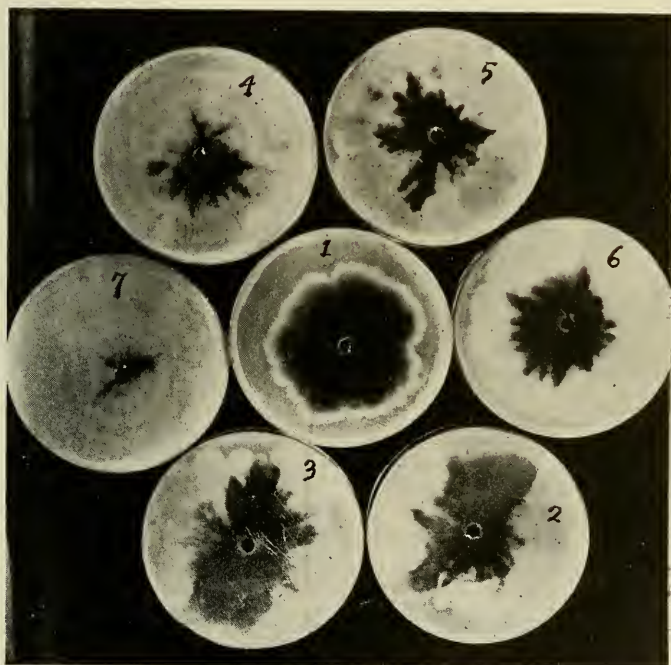


FIG. 3—Seven colonies of the same culture dissociating into purple and white variants. The holes in the center of each colony show the regions from which the inoculum discs were cut to be used in the successive transfer series shown in Fig. 4.

In order to test the potentiality of a given piece of inoculum in regard to its ability to produce the two types of cultures, the following experiment was made: seven sectoring colonies (Fig. 3), each showing purple and colorless sectors, were selected; by means of a cork borer with a bore of 5 mm., inoculum discs were cut from the purple region and transferred to seven petri dishes containing the same kind of

nutrient agar. Twenty-four hours later these inoculum discs were removed and transferred to another series of dishes. This was continued seven times, thus yielding 49 cultures, seven consecutive transfers being made in each one of the seven original cultures. As can be seen in Figure 4, only series 4, 6, and 7 showed a similarity of growth, while the remaining four series gave rise to both sectoring and seemingly pure colonies. It is interesting to note that in no case was there a pure colony of the colorless type. One would be inclined to assume that the colorless type represented the fluctuating phase, while the purple type was the more stable sort. Furthermore, it can be seen that a given piece of inoculum represents not a standardized unit, but one which may do one thing today and something else tomorrow.

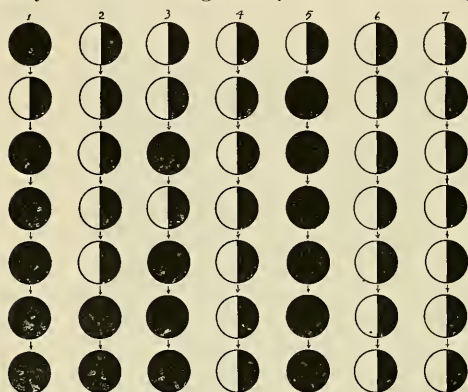


FIG. 4—Diagram showing the result of successive transfers of inoculum discs cut from the colonies illustrated in Fig. 3. The solid discs represent pure purple colonies, while black and white discs represent colonies which variously sector into purple and white variants. Note the absence of pure white colonies.

Since a piece of inoculum, no matter how small, consists of aggregates of many hyphae, and each hypha consists of a great many cells, one may be justified in assuming that the chances for the presence of different characters are greater in a piece of inoculum than they are in a single spore. A series of single spore cultures therefore was initiated. Since all strains used in this work formed no other type of spores except microconidia, cultures from single-celled units were made more reasonably certain. The original culture consisted of a sectoring colony; 20 single spore cultures were made from the purple sector, and fifteen from the white sector. All twenty cultures from the purple sector produced purple colonies. Then for three successive generations twenty single spore cultures were made from one of pure purple colonies, and invariably in all cases pure purple colonies were the result. In the case of the original white sector, however, two of the fifteen single spore cultures yielded pure purple colonies; successive single spore cultures for three generations gave nothing but pure purple colonies. Three of the remaining cultures showed a sectoring habit; twenty single spore cultures from the purple sector of one of these cultures yielded nothing but pure purple colonies, and in three successive generations no variation was noted in all the 60 single spore cultures made. Of the twenty single spore cultures made from the white sector, fourteen were all white, and six showed a sectoring habit.

Single spore cultures made from the white culture for two successive generations yielded nothing but white colonies. Similar cultures made from the two sectors of one of the six sectoring colonies gave rise to pure white, pure purple, and sectoring progenies. One of the ten white colonies resulting from the white sector of the original culture yielded nineteen white colonies and one sectoring colony. Single spore cultures made from one of the nineteen white colonies yielded nothing but white colonies. Cultures made from the purple sector of the one sectoring colony yielded fifteen pure purple, one pure white, and four sectoring colonies; twenty single spore cultures from one of the whites yielded only white colonies, and as many cultures made from the purple colony gave only purple colonies. The twenty single spore cultures made from the white sector of the colony yielded one sectoring colony and nineteen white colonies; twenty single spore cultures made from one of these white colonies yielded nothing but white colonies. Figure 5 represents a diagrammatical behavior of these organisms.

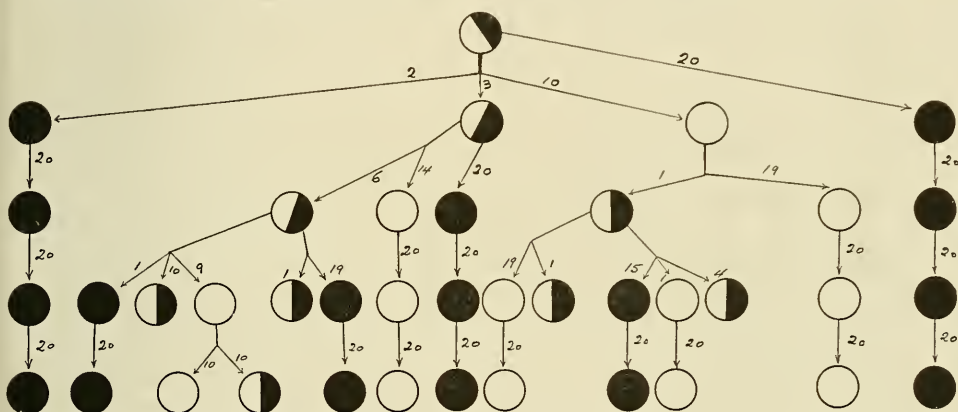


FIG. 5—Diagram illustrating the behavior of single spore cultures made from the two sectors of one of the dissociating colonies shown in Fig. 4. Arrows indicate the course of successive transfers, while Arabic numerals represent the number of single spore cultures made in each series and show the number of cultures which were pure white, pure purple, or sectoring.

Thus it can be seen that in so far as this particular instance is concerned, single spore selections tend to "purify" the line and to eliminate the constantly fluctuating habit of the original colony. However, the writer is reluctant to believe that this fixing of the type is a permanent one, as he has studied many cases where seemingly stabilized cultures suddenly and without any apparent cause resumed their former fluctuability, upsetting many nicely formulated notions. In fact, at the time of this writing, the white dissociant is already showing signs of reversion: some of the colonies are now beginning to show rays of deep purple radiating through the colorless submerged hyphae. Undoubtedly a purple sector will eventually separate itself to begin the cycle all over again. Nor is the purple dissociant constant; while it has,

as yet, shown no direct indications of reversal, it has, nevertheless, dissociated into new types and new shades of color.

Such complexity of behavior and morphology manifested by *Fusarium moniliforme*, as well as by many other fungi, is difficult to understand especially by those who instinctively cling to the belief that a given organism is rigid and immutable. These propose environmental stimuli, contamination, degeneration, hybridization, mutation, and mixochimaera as logical explanations of dissociative phenomena. No one doubts that different environmental conditions may serve to bring about striking modifications in the behavior and appearance of fungi; but when such modifications appear in the form of sectors in the same colony and under identical conditions, it becomes necessary to search elsewhere for an adequate explanation. Some workers are of the opinion that dissociations occur only on special types of rich substrata, and that the avoidance of such foods will eliminate dissociations; but the masking effect of different substrata has not been properly appreciated. An opaque substratum like oatmeal agar for instance will mask variations in the colony form; color production is masked by some agars and intensified by others; aerial hyphae, rate of growth, and almost any macroscopic character may be similarly masked or intensified. We cannot say that because a given substratum discourages color production, color has been eliminated. An organism may sector off a color-producing strain, but because of the unfavorable nature of the substratum, such a sector may escape notice; yet if accidentally transferred to a new tube of agar this new dissociant may be perpetuated, leading the worker to think that he is dealing with "new" or "abnormal" appearances and behaviors. The so-called "running out" of pure cultures is very often to be directly ascribed to such a phenomenon.

The oft-repeated and least valuable of all explanations is the one whereby contaminations and possible mixtures of strains are held to be the cause of dissociations. The periodicity of the dissociating habit, constant fluctuations back and forth within the behavior of a given single spore culture, and the tendency of mixed organisms to sector away from one another and to remain pure after once sectoring, speak convincingly against such a theory. Some believe that even a single spore culture is not necessarily pure; that a spore may have more than one nucleus, each nucleus coming from a different species, variety, or biotype. If we once allow ourselves to go thus far, then what is to prevent us from saying that even a nucleus may be a mixture of chromosomes of different specific affinities, and that a single chromosome may have a mixture of genes of diverse specific affiliations? Furthermore, when 10, 50, 100 or more dissociants can be isolated from a single spore culture, it becomes unreasonable to assume that the nuclei of so many "different" organisms can be crowded within the confines of a single spore.

Involution forms and degenerative phases abound more in bacteriological literature than in mycological writings. However, bacteriologists are coming to realize that the so-called involution forms

constitute regular and important phases in the cyclogeny of bacteria, and that such phases are just as normal as the usual text-book concept of normal cells.

Particularly in the case of organisms where sexuality does not occur, the theory of hybridization can summarily be eliminated. Even where sexuality does exist and heterothallism is a fact, hybridization and subsequent segregation of hybrid characters can still be disregarded in so far as their effect upon dissociations in pure cultures is concerned. There are too many cases showing that single spore cultures of a given strain may remain remarkably stable for months and even for years, but may eventually dissociate into new forms without ever coming in contact with other strains capable of bringing about hybridization.

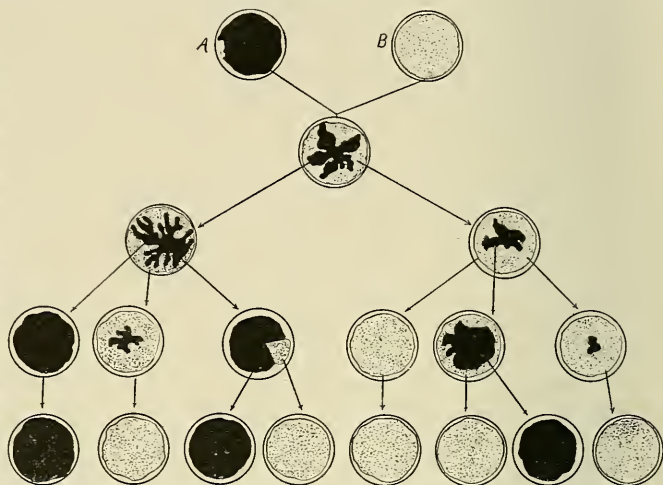
The word "mutation" is no longer an explanation: mutation differs from variability merely by the degree of its intensity and permanency; it still remains to be proved experimentally that a mutant is more stable than a dissociant. We do not know why an organism mutates; neither can we explain why another organism dissociates. Therefore, by saying that dissociations are some form of mutation, we are not solving a puzzling question but are advancing another puzzle.

Perhaps the most far-fetched theory is that advanced by Brierly (2,3) and termed by him "mixochimaera." According to this hypothesis a somatic fusion between the hyphae of different organisms may give rise to a race possessing some new characteristics. However, it must first be demonstrated that a fusion of cell walls is a forerunner of nuclear fusion or even of a nuclear or protoplasmic migration. There is no biological basis for such an occurrence outside of sexual fusions; Brierly backs his hypothesis not with experimental data, but merely speculation. Artificially induced somatic fusions are quite common in horticultural practices where many different kinds of grafts have been made between different plants. Yet it has repeatedly been demonstrated that the understock cannot influence the hereditary makeup of the scion, and Winkler has shown that the chromosome number of each species united to form a chimaera remains absolutely unaltered.

It is true that chimaeras do occur and can be artificially induced, but there is no analogy between chimaeras and dissociants. The former do not reveal new genotypic departures; the cells of the two uniting tissues remain distinct and their hereditary potentialities remain as pure and as unaltered as if no chimaeral association had ever occurred. In the vegetative thalli of most fungi there is not even a rudimentary tissue system, and consequently chimaeras, as we know them in higher plants, cannot at all be conceived. Even if the mixing of the nuclei of different biotypes and varieties did follow as a result of somatic fusions, each nucleus would then act independently and would, eventually, either outgrow all others or be left behind. Needless to say, new biotypes could not be synthesized as a result of such nuclear mixture. Before we can even consider the hypothesis of mixochimaera, we must be able to demonstrate that two fungi, when grown together or when

mated by sexual attraction, will continue to remain closely associated in subsequent transfers and vegetative propagations. The writer (11) has demonstrated that such a permanent association is impossible not only in artificially mixed cultures of *Fusarium moniliforme* (Fig. 6) but also (12) in heterothallic strains of *Phytophthora*, and that the one or the other of the strains will eventually sector away and remain free of the invasion of the hyphae of the opposite sex.

FIG. 6 — Sketch showing artificial synthesis of dissociation. *Fusarium moniliforme* biotype A (purple) and biotype B (orange) were thoroughly mixed; small bits of this mixture were transferred to nutrient agar plates. Some of the results are illustrated in this diagram: in the first generation transfer there is a complex colony consisting of an irregular purple growth surrounded with orange growth. Transfers from orange and



purple sections of the colony again yielded complex colonies. In the third transfer series two pure colonies and four complex colonies resulted, while in the last transfer series all colonies were pure and subsequent transfers for several generations failed to yield any sectoring or reversing colonies. This behavior is the result of a mere mechanical mixture of the two biotypes which struggle to free themselves from one another, eventually sectoring away or outgrowing the one or the other.

Some workers have attempted to minimize the importance and the frequency of dissociations. Coons and Strong (4), for instance, working with 54 species and varieties of *Fusarium* represented by 104 accessions, report diametrically opposite results to those obtained by the writer (10). They state that in their hands the cultures of *Fusarium* failed to show dissociations, and that their results did not manifest any inconstancy. But apparently Coons and Strong did not become aware of the possibility of dissociation in Fusaria until the bulk of their cultural work was completed. For instead of examining their own cultures for signs of sectoring, they resorted to photographs taken earlier during their studies. Photographs are indeed poor witnesses to bring against dissociation phenomena. An examination of plates in the publication by Coons and Strong shows numerous indications of dissociations which completely escaped the notice of the authors, as can be readily seen in the following: Plate I, illustration D, the lower right colony; Plate II, illustration D, upper right and the lower two colonies; Plate III, illustration C, the lower two colonies; Plate IV, illustration F, the lower

left colony; Plate V, illustration E, the lower right colony; Plate VI, illustration B, all four colonies, illustration E, the upper two colonies, and illustration F, the upper right colony; Plate VII, illustration A, the upper two and the lower right colony; illustration B, all four colonies, and illustration C, the lower left colony.

As concerns uniformity of results which Coons and Strong claim to have obtained throughout their work, let their own illustrations speak for themselves: In Plate I, illustration E, of the four plantings one grew well, another poorly, the third showed merely a trace of growth, and the fourth failed to grow; in illustration B two grew, two failed to grow; in illustration F one grew, three failed to grow. Plate II, illustration C shows three plantings of which two grew and the third failed to grow. In Plate IV, illustration F, three plantings grew and one did not. In Plate V, illustration F, two grew and two failed to grow. The writer does not understand how Coons and Strong could state that their experiments "have not revealed such a state of inconstancy" when their own illustrations show such disconcerting behaviors.

There is a common notion that dissociants play havoc with taxonomy; on the contrary, they are of inestimable aid in bringing order out of chaos. Any genus or species which has a firm foundation is not at all affected by dissociations. Unfortunately, however, the taxonomic literature is submerged under a deluge of new genera, species, and varieties that are based on trivial, insignificant, or not readily discernible differences. It is only in such cases that dissociants help to demolish the superstructure of worthless species.

Dissociation is no more mysterious or unusual than variability; after all, an organism should contain within its protoplasm all the characteristics of the species; otherwise the theory of evolution would lose significance. Of course, it is not possible for all such specific characters to manifest themselves at one time; but the possibility is there. For instance, the potentiality for pigment production in the case of *Fusarium moniliforme* ranges through salmon, orange, red-purple, purple, lavender, blue-green, or lack of color. Therefore no one who knows this species is surprised if the different biotypes of *F. moniliforme* produce these colors. But when a sectoring colony produces one or two of these pigments, the phenomenon is regarded as mysterious. Since all these different pigments are associated with the species, and since the living protoplasm cannot acquire new characters under environmental conditions unless the potentiality for the manifestation of such characters is already present, why should not any strain of *F. moniliforme*, over a more or less extended period, manifest any or all of these colors? It is true that certain dissociants or certain isolants once obtained in pure culture may remain fairly constant in their behavior, but we have seen that a continued selection tends to fix even the most fluctuating sorts, even though the fixation and purity be comparatively relative and no more specific than the so-called impure character which has been made to submerge.

Those who are loathe to accept dissociation phenomena as fact must regard the species either as absolutely rigid and immutable, or as plastic. If the former, they must subscribe to the doctrine of special creations; if the latter, they must admit that the isolant has all the potentialities of the species even though it may be unable to express all of them at a time. Once this is accepted, then the dissociative phenomenon becomes a matter of course.

Dissociation is that phenomenon whereby a given organism traces the sphere of variability of the species. It should be regarded as a highly normal and natural behavior. Since all species are more or less variable, they should all dissociate if given the right environment. No two members of a given species are absolutely identical; if we could employ sufficiently refined tests we would probably be enabled to detect differences between any two isolants of the same variety. Dissociations serve to bring forth such differences and to enlarge our species concept.

The reason why many of us have been under the impression that dissociations yield new forms, or that certain unusual departures shown by these dissociants are new, is that we have only an imperfect or one-sided knowledge concerning the potentialities of the species. We have been in the habit of describing the species according to its morphological characters; we have usually failed to make intensive cultural studies, and have endeavored to formulate fundamental truths by superficial observations. To many of us form and size of spores and reproductive bodies constitute the sum total of the mycological concept, and the vital life processes of fungi have little taxonomic value in our scheme of classification.

Many of us, despite our professed liberalism, still cling to the notion that a species is as it appears to us at a given time. While any organism is a unit in itself, it may, nevertheless, exhibit only one or just a few of its component phases at a time. Therefore, any genotypic strain or biotype by itself and at any one time, may not reveal the entire sphere of the species, but only a few of the units which form the specific sphere. The biotype therefore may often constitute but a fragment of a unit, only one part of a panorama; in other words, a dissociant illustrates only one phase of the species. The hypothetical composite formed by all possible dissociants should be considered the biotype, just as the hypothetical composite of all possible biotypes should be considered the species. Consequently, when a culture dissociates, it merely reveals some other character of the species, and nothing more.

Intensive cultural work with scores of dissociants has shown a remarkable continuity of specific characters, with no indication to justify the assumption that anything new has been introduced into the hereditary makeup of the species. Too long have we been chained to type species; too long have we let the mere accident of a first discovery and description shape our taxonomic concept. If instead of one, we had 100 types for each species, it would be possible for us to see that any dissociant may have its counterpart among the 100 types which form

our composite species. According to such a scheme *Fusarium moniliforme* would be recognized as nothing else but *F. moniliforme* regardless of whether it parasitizes corn or fig, banana or pineapple; whether it is a soil-inhabiting, harmless saprophyte; whether its colonies produce yellow, salmon, pink, purple, blue-green pigments, or no pigments; whether there is a profusion of aerial hyphae or no such hyphae; whether sporodochia or pseudopionnotes form or no such bodies develop; whether macroconidia are present or not; whether the fungus is a rapid or slow grower; whether the thermal death point is a little above or a little below a certain thermal death point; and whether the size and shape of macroconidia resemble the picture conveyed by the texts, or whether they vary. Despite all these variations, the monilioid microconidia, coupled with total absence of chlamydospores, form a specific continuity whereby we readily recognize *Fusarium moniliforme*. But this continuity becomes tangled once we begin to create varieties and spread thinner the already insufficient specific characters for the sake of creating new varieties or new species.

SUMMARY

Out of 150 isolations made from corn seedlings, 110 proved to be *F. moniliforme*, 20 *F. culmorum*, and the remaining consisted of various saprophytic forms.

Only 20 strains of the foregoing 110 cultures of *F. moniliforme* proved to be pathogenic to corn.

Successful inoculations were possible largely through wounds.

Seedlings wilted only when inoculated at the base of the stem just below the surface of the ground. Root inoculations yielded only localized infections.

Even when newly germinated seedlings were kept on a vigorously growing colony of the fungus in petri dishes and transplanted into the field after most of the roots were infected, they grew into normal plants.

Comparatively low temperatures (20-23°C.) were necessary for successful inoculations. No or little infection occurred at higher temperatures.

Even the most vigorous strains exhibited their pathogenicity in cycles; at one time they were able to infect the host, at another time and under identical conditions they failed to do so.

Most strains of *F. moniliforme* were extremely plastic and dissociated into many forms. One single-spore isolation produced as many as 50 variants which differed not only in their pathogenicity but also in morphological and physiological characters as well.

Single spore culture selections from the most variable types tended to fix the fluctuating types, although it is doubtful if this fixed habit becomes a permanent one.

Late planting to avoid cool, wet soil conditions seemed to be the best method to avoid seedling losses caused by this fungus.

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